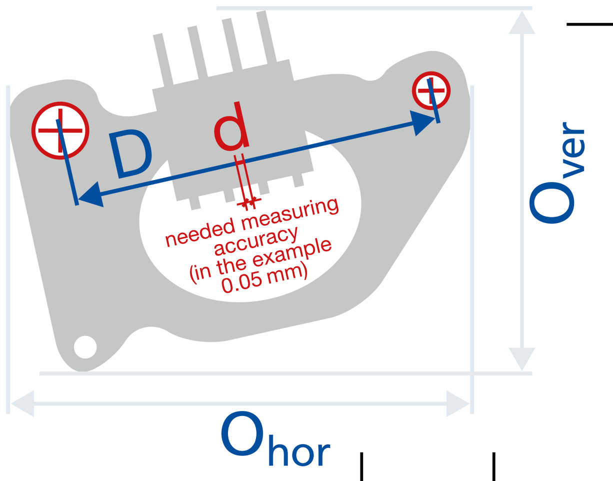
MACHINE VISION NAVIGATOR

A brand of Balluff

The way to the right camera STEP 1 – 6



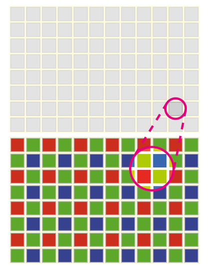
Glossary
(in alphabetical order)
D = Measurand (distance) [mm]
d = Object detail size [mm]
f = Focal length [mm]
I = Sensor size [mm]
N = Minimum amount of pixels per object detail
n = Permitted number of blur pixels
O = Object size [mm]
p = Pixel size [mm]
S = Resolution of the sensor in pixels
t = Exposure time [s]
v = Speed [mm/s]
w = Object distance [mm]

STEP 1
Task

Measuring
In the shown task, distance D between the centers of both holes shall be determined with the measuring accuracy d. For this, you have to determine the needed sensor and camera parameters.

Task example: Measurement
Distance (D) between 2 points with measuring accuracy (d) of 0.05 mm. Object size O_{hor} = 48 mm (monochrome sensor, because color is not relevant here)

Background knowledge: Monochrome or color?
Color sensors use a Bayer color filter, which allows that only one basic color reaches each pixel. The missing colors are determined using interpolation of the neighboring pixels. Monochrome sensors are twice as light sensitive as color sensors and lead to a sharper image or acquire more details with the same amount of pixels. For this reason, monochrome sensors are recommended as long as no color information are needed.



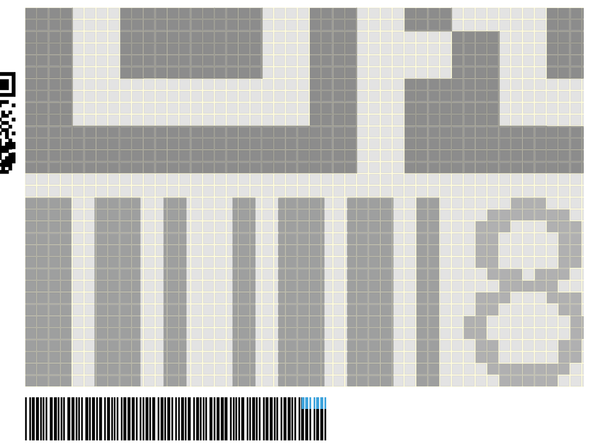
STEP 2
Amount of information

Minimum of pixels per Object detail — **Monochrom**

Object detail measuring / detection	3
Barcode line width	2
Datamatrix code module width	4
OCR character height	16

Needed amount of information Example:
The measuring needs 3 pixels for the necessary accuracy (object detail size d). As necessary accuracy, "d" – which is 0.05 mm in this example, is imaged on 3 pixels.

Background knowledge: Minimum number of pixels.
To avoid the loss of information through sampling blurs, there is always a minimum number of pixels for each characteristic necessary.



STEP 3
Sensor resolution

Formula for calculating the sensor resolution

$$S = \frac{N \times O}{d} = \frac{\text{min. number of pixels per object detail} \times \text{object size}}{\text{object detail size}}$$

Define object size orientation – horizontally or vertically

Sensor resolution in pixels example:

$$S = \frac{3 \times 48\ \text{mm}}{0.05\ \text{mm}} = 2880\ \text{(pixels)}$$

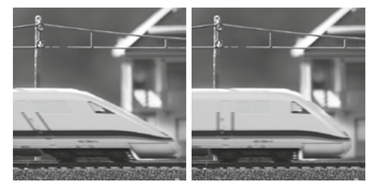
For list of available sensors, see table on www.matrix-vision.com/camera-selector.html: 3096 x 2080, 6.4 MPixels, 1/1.8", 7.4 x 5.0 mm

Background knowledge: Sensor alignment in portrait or landscape format?
For the calculation you have to define which orientation horizontal or vertical – shall be decisive.

Size	Dimensions	Diagonal
1/3"	4.8 x 3.6 mm	6 mm
1/2.5"	5.8 x 4.3 mm	7.2 mm
1/2"	6.4 x 4.8 mm	8 mm
1/1.8"	7.4 x 5.0 mm	8.9 mm
2/3"	8.8 x 6.6 mm	11 mm
1/1.2"	11.3 x 7.1 mm	13.4 mm
1"	12.8 x 9.3 mm	15.8 mm
1.1"	14.2 x 10.4 mm	17.6 mm
4/3"	18.9 x 10.7 mm	21.7 mm
APS-C	22.3 x 16.7 mm	27.9 mm

STEP 4
Shutter technology

Global shutter versus rolling shutter?
Rolling shutters expose the motive line-by-line. This procedure results in a time delay for each acquired line. Thus, moving objects are displayed blurrily in the resulting motive through the generated "object time offset" (compare to the image). Global shutter is used to get distortion-free images by exposing all pixels at the same time. Rolling shutter sensors are more light sensitive and less expensive compared to global shutter sensors.


Rolling Shutter Global Shutter

STEP 5
Interfaces and camera selector

Camera series	mvBlueCOUGAR-X (PoE)	mvBlueCOUGAR-X-POE-I	mvBlueCOUGAR-XD	mvBlueFOX-IGC	mvBlueFOX3-MLC
Interface	GigE	GigE mit M12	Dual-GigE	USB 2.0	USB 2.0
Distance to the processing unit	max. 100 m	max. 100 m	max. 100 m	max. 5 m	max. 5 m
Bandwidth[2] (net)	120 MB/s	120 MB/s	240 MB/s	30 MB/s	30 MB/s

Camera series	mvBlueFOX3-1	mvBlueFOX3-2	mvBlueFOX3-4	mvBlueFOX3-3M	mvBlueFOX3-5M
Interface	USB 3.x	USB 3.x	USB 3.x	USB 3.x	USB 3.x
Distance to the processing unit	max. 8 m... max. 50 m[1]	max. 8 m... max. 50 m[1]	max. 8 m... max. 50 m[1]	max. 8 m... max. 50 m[1]	max. 8 m... max. 50 m[1]
Bandwidth[2] (net)	300 MB/s	300 MB/s	300 MB/s	300 MB/s	300 MB/s

[1] max. 50 m with active optical connection
[2] bandwidth = resolution x frame rate x bit depth

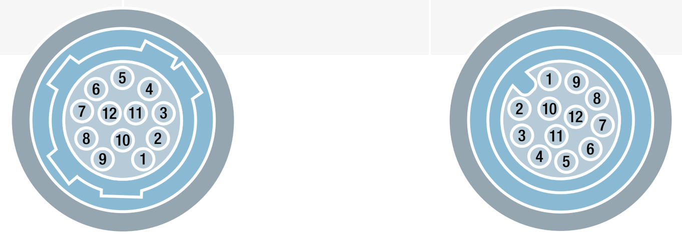
www.matrix-vision.com/kamera-selektor.html

STEP 6
Peripherals

Pinning

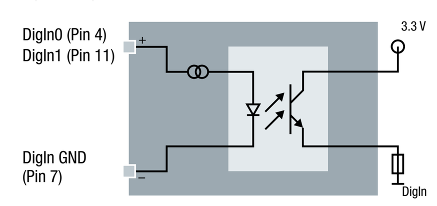
Pin	Standard (Hirose)	POE Option (Hirose)	POE-I Option (M12)
1	GND	GND	PWR_IN
2	PWR_IN (not connected mvBlueFOX3-1)	PWR_IN	GND
3	DigOut3 (wxPropView numbering: line3)	Reserved	DigOut3 (line3)
4	Opto DigIn0 (line4)	Opto DigIn0 (line4)	Opto DigIn0 (line4)
5	DigOut2 (line2)	N.C.	DigOut2 (line2)
6	DigOut0 (line0)	Opto DigOut0 (line0)	DigOut0 (line0)
7	Opto DigIn_GND	Opto DigIn_GND	Opto DigIn_GND
8	RS232 RX (Opto DigIn2 for PLC option)	RS232 RX	Opto DigIn2 (line6)
9	RS232 TX (Opto DigIn3 for PLC option)	RS232 TX	Opto DigIn3 (line7)
10	DigOut_PWR_IN	Opto DigOut_PWR_IN	DigOut_PWR_IN
11	Opto DigIn1 (line5)	Opto DigIn1 (line5)	Opto DigIn1 (line5)
12	DigOut1 (line1)	Opto DigOut1 (line1)	DigOut1 (line1)

Connector



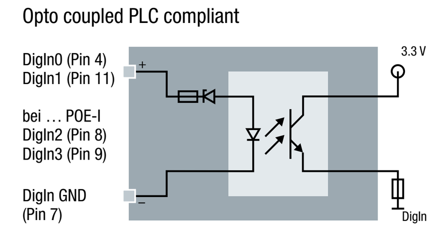
Digital Input

Opto coupled



mvBlueCOUGAR-X · mvBlueCOUGAR-X POE
mvBlueFOX3

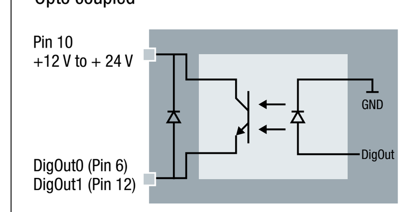
Opto coupled PLC compliant



mvBlueCOUGAR-X PLC option
mvBlueCOUGAR-X POE-I (IP67C)

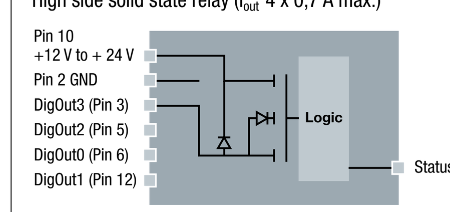
Digital Output

Opto coupled



mvBlueCOUGAR-X POE
mvBlueFOX3

High side solid state relay (I_{out} 4 x 0,7 A max.)



mvBlueCOUGAR-X
mvBlueCOUGAR-X POE-I (IP67C)

The way to the right lens STEP 7 – 9

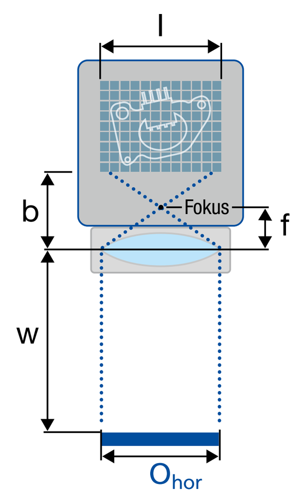
STEP 7
Lens focal length

Approximation formula for calculating the focal length:

$$f = \frac{w \times I}{(O + I)} = \frac{\text{object distance} \times \text{sensor size}}{(\text{object size} + \text{sensor size})}$$

Focal length example:

$$f = \frac{120\ \text{mm} \times 7.4\ \text{mm}}{(48\ \text{mm} + 7.4\ \text{mm})} \quad f = 16\ \text{mm}$$

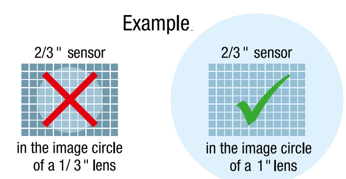


STEP 8
Lens connection

Sensor size	Lens mount
bis 1/2"	S-mount (M12)
bis 1"	C-/CS-mount
APS-C	T-mount (M42)
	F-mount (Bajonett)

Lens connection example:
Dependent on the sensor used, a lens mount corresponding to the sensors size is needed.

Example



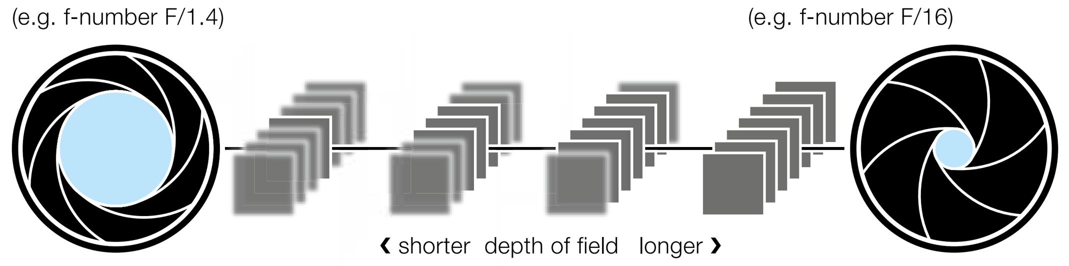
www.matrix-vision.com/lens-calculator.html

STEP 9
Aperture setting

Effect of aperture
The aperture influences the brightness of the image. The aperture also holds way over depth of field and the need for light during the image acquisition (see image on the left: "Effect of aperture/depth of field"). Small apertures should be avoided because they lead to bending effects which result in blurry images. A wide open aperture leads to a very low depth of field.

Aperture setting example: Measuring points are on one level.
A smaller depth of field is necessary. For this reason, a larger aperture can be used.

large aperture (e.g. f-number F/1.4) — **Effect of aperture** — **small aperture** (e.g. f-number F/16)



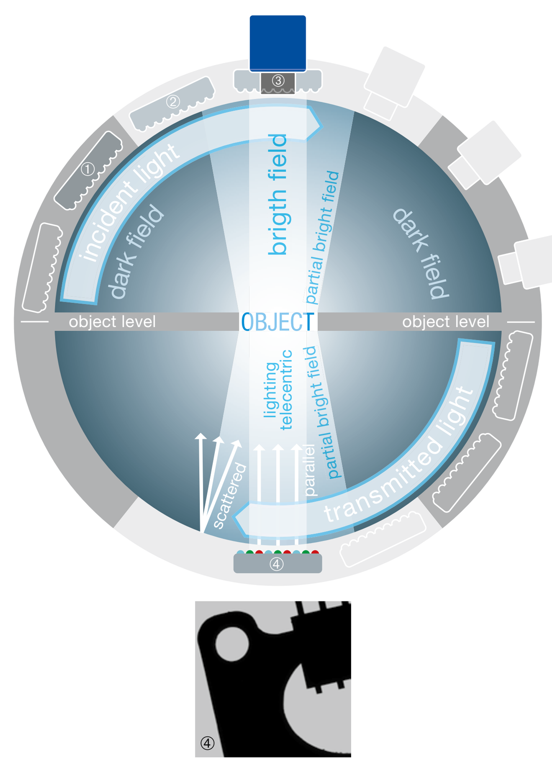
high light intensity on sensor (short exposure or reduce amount of light)
relative image brightness ‹ increasing / decreasing › at same lumen value
low light intensity on sensor (long exposure or increase amount of light)

The right lighting STEP 10 – 11

STEP 10
Lighting type

Incident or transmitted light?
The type of lighting and the lighting angle are crucial in determining whether the characteristics of the item become visible and evaluable in the image or not. It has to be decided to light from the direction of the camera (incident light) or light the object from behind (transmitted light). Because of the lighting angle, incident light can highlight contours on the surface. To avoid shadowing with high objects, the usage of telecentric lightings and telecentric lenses is more appropriate.

Lighting example: Flat object – Measuring the distance between two holes
Choice of lighting: brightfield illumination transmitted light.



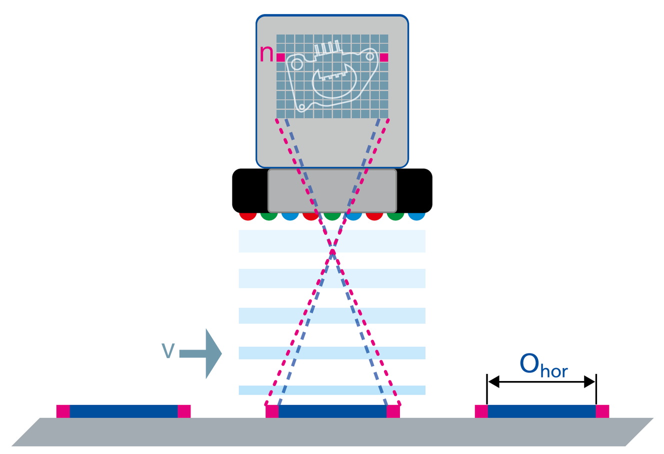
STEP 11
Exposure time

Formula for calculating the exposure time of moving objects:

$$t = \frac{n \times p \times O}{I \times v} = \frac{\text{permitted number of blur pixels} \times \text{pixel size} \times \text{object size}}{\text{sensor size} \times \text{speed}}$$

Exposure time example:
Permitted number of blur pixels = 3 (target)
Pixel size p = 4.5 µm = 0.045 mm (from camera data sheet)
Object size (horizontally) O = 48 mm
Sensor size (horizontally) I = 7.4 mm
(from camera data sheet) Speed v = 100 mm/s

$$t = \frac{3 \times 0.045\ \text{mm} \times 48\ \text{mm}}{7.4\ \text{mm} \times 100\ \text{mm/s}} = 0.0087\ \text{s} \approx 9\ \text{ms}$$



RESULT
STEP 1 – 11

Result summary STEP 1 – 11

Camera model: ______________

Lens focal length: ______________

Lens mount: ☐ S-mount (M12) ☐ C/CS-mount ☐ T-mount (M42) ☐ F-mount (bayonet)

Lighting: ☐ Incident light ☐ Transmitted light ☐ Bright field ☐ Dark field

Exposure time: ______________

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